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AUTOMATIC SPLICES – THE INSIDE STORY

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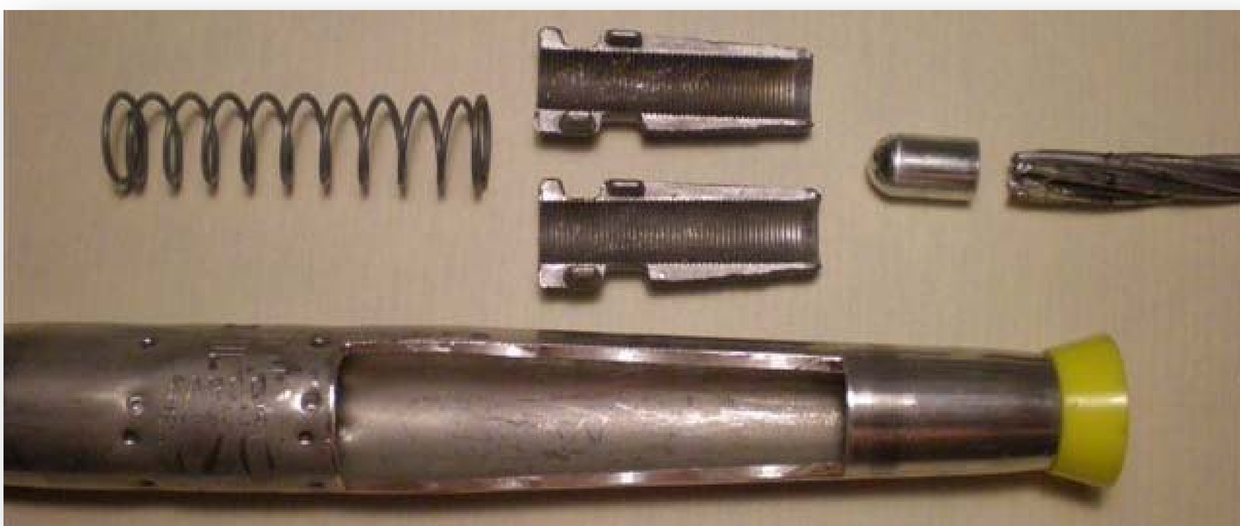
We wish to begin by stating our position clearly: "Properly installed, automatic splices are predominantly reliable." We have also stated that automatic splices are "a must – for storm restoration." They are, without question, the most economical, and certainly the fastest means of reliably splicing a conductor. Do other methods, such as compression connectors, offer a higher integrity connection? I think that the manufacturers of automatics would agree that is the case – as they also offer the compression option – but nobody would argue against the importance of the "quick" means afforded by the automatic splice – and at no time is this option more appreciated than following a storm event which caused a widespread outage!

How the "Automatic Splice" Works

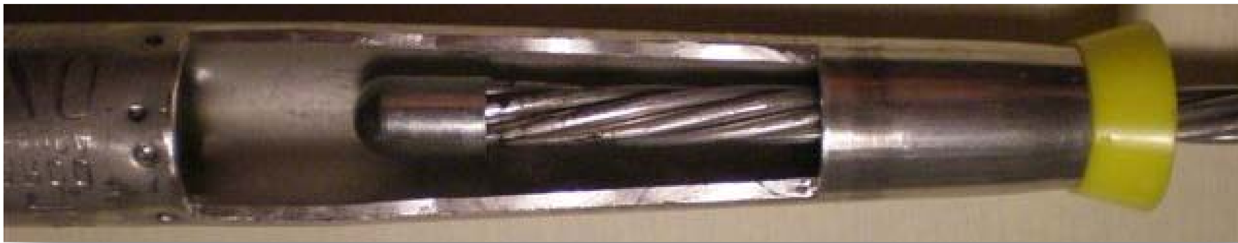
Most linemen who install automatic splices know what is inside, but perhaps if we discuss these components in detail, it will assist them when installing these connectors, to understand the purpose of the components, and possibly give them a bit more appreciation for the manufacturer's instructions!

The following is a picture of the "guts" of one side of an automatic – the other side is the same.



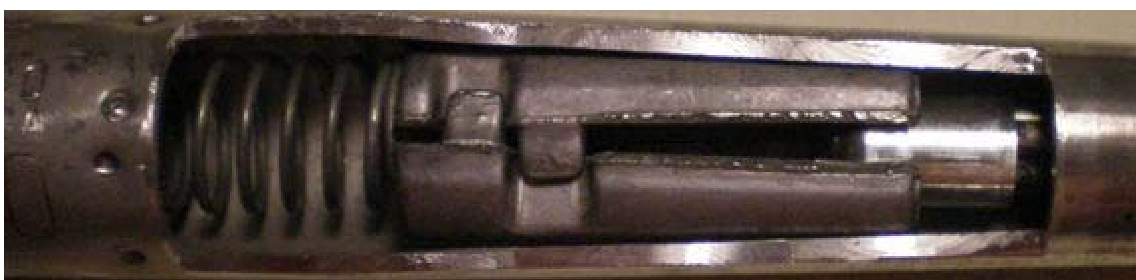
Beginning at the upper left and moving clockwise, we have (a) the spring, which provides a forward thrust to the jaw assembly during installation, (b) two jaws which interlock and make up the "jaw assembly", (c) the pilot cup, which captures the ends of the conductor strands, and maintains their position (keeps them together) during the installation, and at the bottom, the yellow component is the "funnel guide" which serves to hold the pilot cup inside the assembly and guide the individual strand ends of the conductor into the pilot cup – all within the tapered body of the splice.

To illustrate the action of the pilot cup, the following photo shows how the conductor, once inserted through the funnel guide, fits within the confines of the pilot cup. As will be discussed in detail later, the function of this pilot cup is critical to a successful installation of an automatic splice.

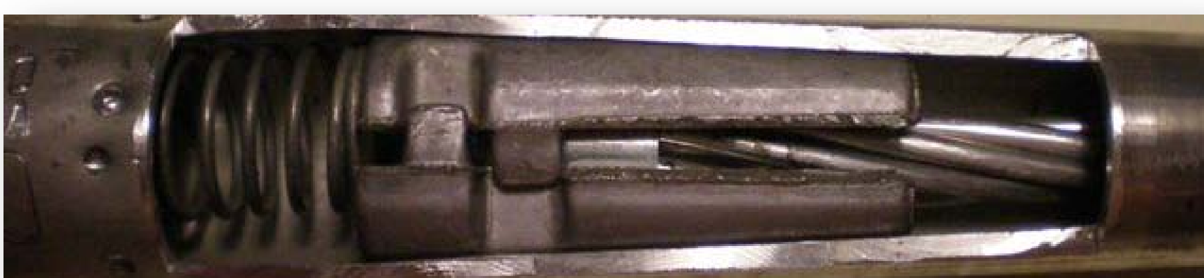


Prior to insertion, having this side cut out from the splice, one can see the position of the jaws, urged forward by the force of the spring, awaiting insertion of the conductor.

Upon insertion of the conductor, having picked up the pilot cup as it passes through the funnel guide, the “resistance” that is felt during installation is the force required to push the jaw assembly backward against the spring.



As can be seen, the pilot cup serves to maintain the conductor’s position, centered within the jaws as it is pushed toward the center of the splice.



Properly installed, the conductor will push the pilot cup completely through the jaws, to the center of the splice. Because the pilot cup must contain the entire conductor, it is obviously of larger diameter than the conductor, and as can be seen in the following photo, upon passing the pilot cup completely through the jaws, the jaw assembly will "spring" forward, and the taper of the body will force the jaws into intimate contact with the conductor! Additional tension on the device will serve to further "seat the jaws" and urge them into increased forced contact with the conductor.

That explains, a bit simplistically, how the automatic splice works! To complete our understanding, we must now examine why they fail.

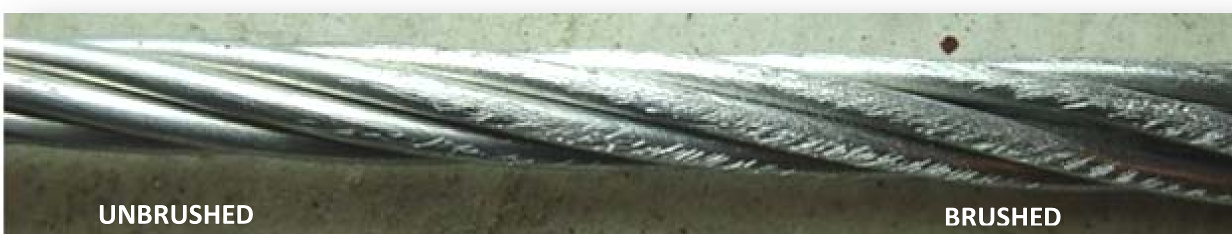
What Goes Wrong with the Automatic Splice?

Improper Selection of Splice for the Conductor

Conductor diameter is critical! To illustrate this key factor, the conductor in this illustration is purposely one size smaller than that intended for this particular splice! Looking carefully at the photo above, one can see that the jaws are completely forced against each other, and cannot be compressed further. Therefore, a complete compression grip cannot be achieved. While this splice would actually hold this conductor under normal line tensions of a few hundred pounds of tensile force, the intended electrical interface contact does not have sufficient force, and will fail prematurely. It is important that only the conductors having a specific diameter within the range specified by the manufacturer be used with a given splice!

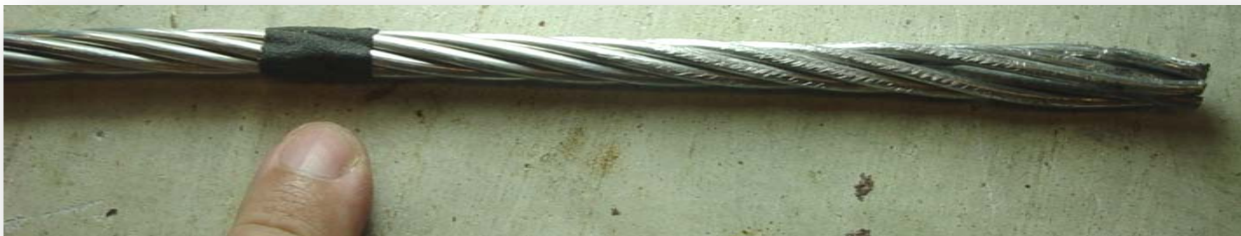
Failure to PREPARE & BRUSH the Conductor

This is the first step in properly installing **any splice or connector**, but this critical step seems to be skipped or neglected more often with automatics than with other connectors. Perhaps it is because so many automatics are installed during storm restoration events, when there is tremendous pressure on the linemen to "get the lines up and power restored" and the job is rushed. There are numerous reports and tests available to assert the importance of this step, so this paper will not go into detail on this, other than to state, that the key result of this operation is not, as many misunderstand, to remove oxides, but rather to "roughen the surface of the conductor" which results in significant improvement of electrical contact at the interface. The difference is EASY to see with the naked eye.



Failure to MARK the Conductor

Also a critical step in any connector, to assure proper insertion depth is achieved, it is perhaps more critical with automatics than with other splices. The reasons for which this paper will explain in more detail! Perhaps it is again, storm restoration and hurried workmanship, or perhaps it is too easy to put ones thumb at the insertion depth… but then something happens, it does not go in as it should, the thumb slips, and the mark is lost. A permanent marker works, but best of all, is a simple piece of tape. Whatever the reason, too many automatics fail due to improper insertion issues.

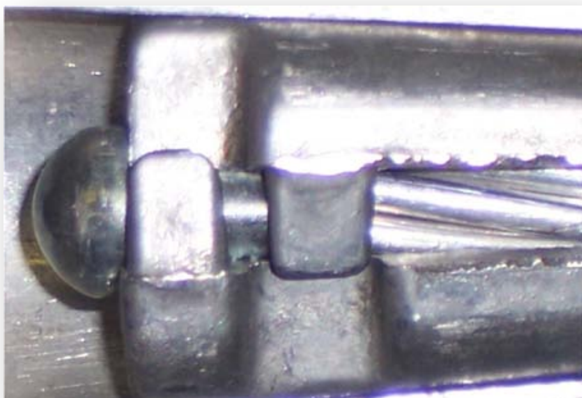


Without question, 75-80% of the problems with automatic splices occur due to installation error, and about 80% of those are "partial insertion" errors. There are two types of "partial insertion errors. The first is an Incomplete Insertion, where the conductor is simply not inserted to its full intended depth such that the pilot cup has not "cleared" the jaws!

(a) Incomplete Insertion

The result is that of the following photos. In the instance of the first photo, insufficient force was provided to drive the pilot cups into the jaws, and the conductor was simply not gripped. If this occurs, the lineman will immediately recognize there is a problem, and take action to correct that, by installing another splice.

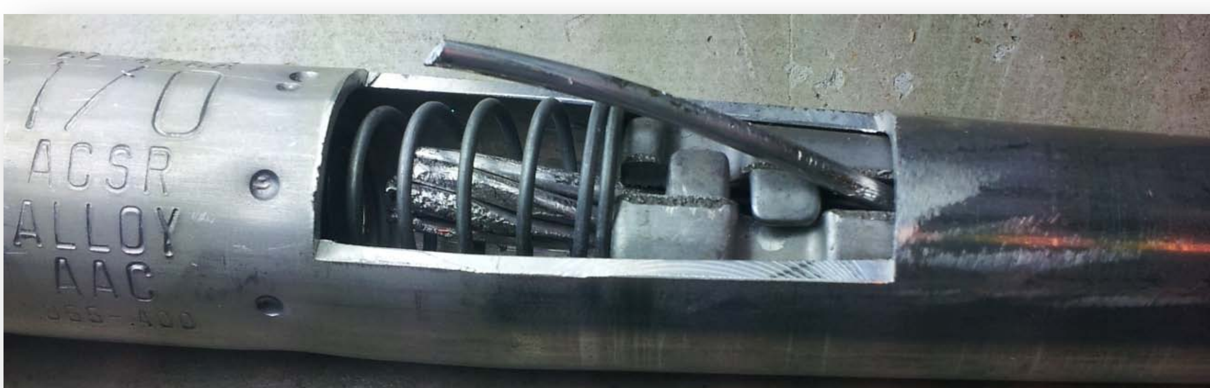
However, in the instance that follows, the pilot cup has passed almost to the end of the jaws, which is the most dangerous situation, as the tips of the jaws may capture the conductor, leading the installer to believe that the splice is made adequately, and the conductor may withstand the initial tension of the line, but the jaws are prevented from closing completely on the conductor by the invading pilot cup! In such instances, the splice may be left in service for days, weeks, or even years, before some event jostles the line sufficiently or components of corrosion build up, thus allowing the conductor to slip out! This condition may be impossible to detect with infrared techniques or direct resistance measurements, depending on the current load on the line.

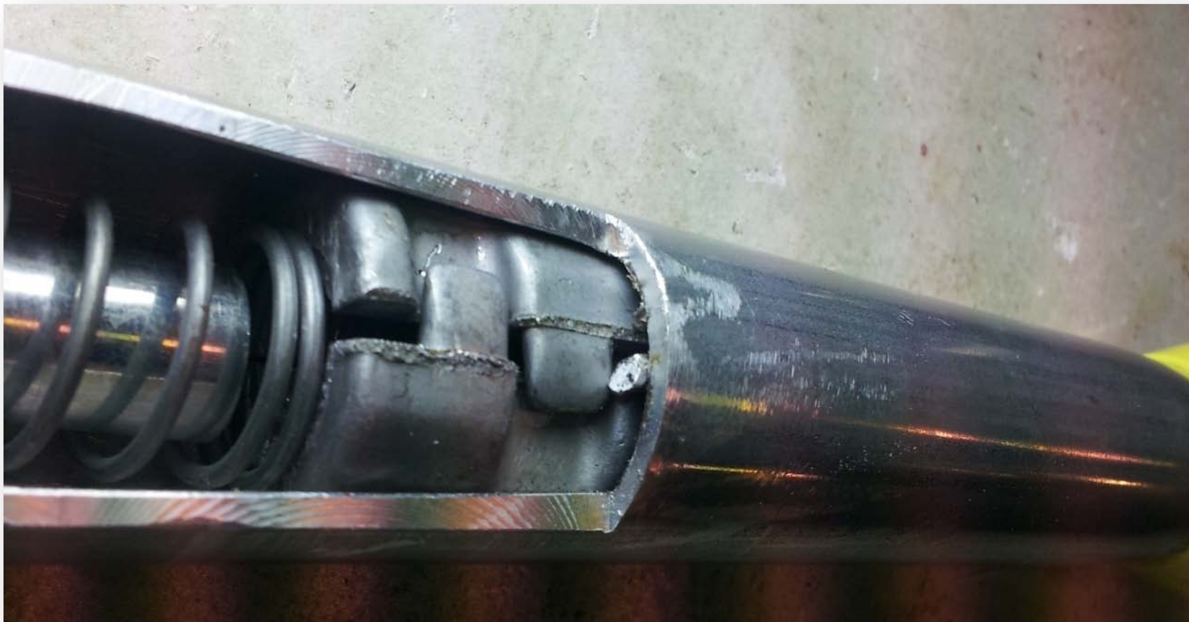


(b) <u>Errant Strand – Partial Insertion Error</u>

A second type of insertion error occurs from time to time, when upon inserting the conductor, the lineman pulls it back a bit (possibly to get a better grip because it was obvious that the conductor did not go in far enough – such as the condition in the previous photo – BUT when that occurs, the pilot cup <u>does not come back</u>, as it is held in the jaws. The purpose of the pilot cup is to keep the ends of the strands together, and assure that they <u>all</u> pass completely through the end. In the scenario where the conductor is retracted as much as ½ inch, the strands can escape from the pilot cup, and one may erroneously slip through the side between the jaws. In this instance, although the conductor may be fully inserted, the errant strand between the jaws prevents them from closing completely, and because it is not within the bundle, the overall diameter is reduced and again, the conductor can slip from the grasp of the jaws.

The following two photos illustrate the above described scenario. More typically, the strand will only be between the jaws, but the result is the same.

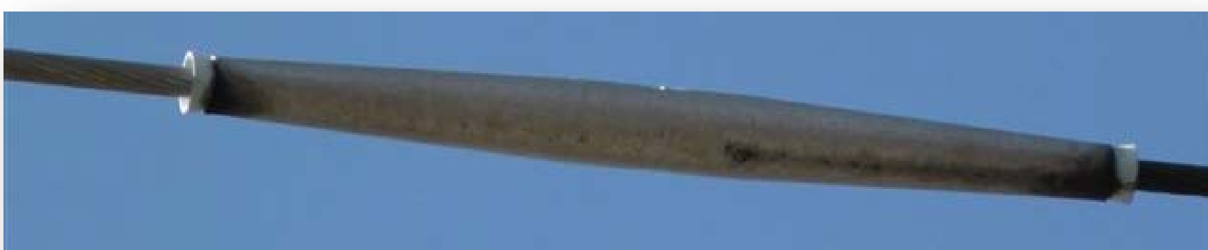




The critical concern is that neither of these situations are visible or otherwise readily detectable, and while the splice may hold the line under the stringing tension of a few hundred pounds, additional tension or other disturbance during work on the line may be enough to allow it to slip.

The old method of putting a set of grips and come-a-long on the line, could in its own movement, cause the line to slip before it is secure. If that occurs, there is an arc flash hazard, along with the fallen conductor. If one puts the MAC cable (ground set used as a jumper cable) on first, it can eliminate the arc flash, but may in itself drop the line.

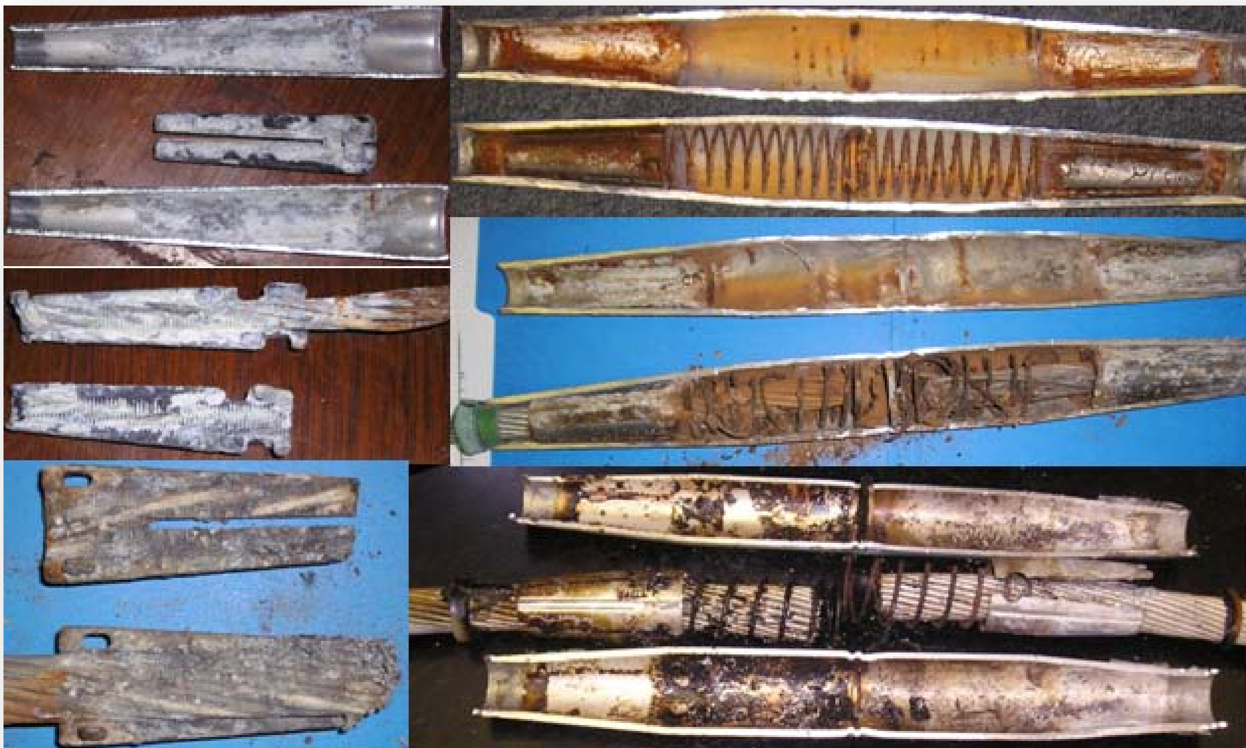
Placing a ClampStar on the line in a gentle fashion allows both the electrical and mechanical safety to be applied at the same time, and is faster and safer to install. If the splice appears bad, i.e., has burnt funnel guides or has evidence of obvious expulsion of contaminants (looks like black grease) running out of it, perhaps it would be wise to simply leave the ClampStar in place!



However, if there is sufficient confidence in the integrity of the splice, the ClampStar can be removed, and used again.

Failure to Use Inhibitor

ALL connectors used on aluminum conductor should have a high quality inhibitor used in the electrical interface. Those that don't will result with a premature failure. Automatics are no exception. While the installer has no options on the interfaces between the jaws and the body, the conductor, should be cleaned and prepared properly, which includes wire brushing and applying inhibitor. Manufacturers have long touted the effectiveness of their "wax" inhibitors. The actual purpose of the wax is a lubricant, and because it does coat the surface, is better than nothing. But, if it is so good, why are the manufacturers now coming out with "Corrosion Proof" or "Corrosion Resistant" automatics? I assure you they are not doing it so save money! They are doing it because of the large number of automatics



"letting go" and finding, post mortem, that they are severely corroded inside.

Again, we must stress, that the installers of the automatics over the past 40 years, that have installed something on the order of 300 Million automatic splices, could have had no effect on the electrical interface between the jaws and the shell. One of the weak points of the automatic is that it has 8 electrical interfaces instead of two like that of the compression splice. The failure point of all connectors is the electrical interface.

An automatic, unless it is located on top of an insulator (which of course it never will be) always has a portion of conductor above it. The airborne contaminants, exhaust, fertilizers, road salt, etc., that settle on that conductor are washed right into the connector when it rains. The water evaporates leaving the contaminants trapped inside! Do you wonder why automatic splices are more prone to corrosion issues than compression? A properly made compression splice is filled with inhibitor – there is no place for that water to get inside.

By its very name, "inhibitor" is critical to the prevention of corrosion in ANY connector, but especially in aluminum automatic splices with aluminum conductor!

Installation in Slack Spans

One does not need much imagination to recognize that the force to create the electrical interface with the tapered jaws of an automatic is derived from the tension of the suspended conductor. Manufacturers warn not to use automatics in slack spans, but driving around most any town, one will see many installations where there is not even enough tension in the span to pull the conductor straight.

These are definitely "installation errors" or more appropriately "application errors" where the wrong device, in these examples an automatic splice, should never have been installed.

Concerns!

All of these instances with the exception of the first and the last CANNOT readily be determined during a post installation inspection!

While difficult, one could, with the use of a micrometer or caliper, accurately measure the conductor to determine if it is within the recommended diameter range of the splice installed. One can ASSUME that the conductor is the specified material assigned to the job, that someone did not make a mistake during the initial installation, that the vendor did not errantly send a spool of conductor that was mismarked. Granted, this is an unusual scenario here in the U.S. and Canada, but it does occur.

And, it is obvious if an automatic is installed in a slack span, that's a no-brainer.

However, the following scenarios are not reasonably assured and some are simply impossible to determine via inspection.

- *Failure to PREPARE & BRUSH the Conductor*
  Other than physically removing the splice, one cannot determine, even with an X-Ray, whether or not the conductor has been properly brushed and prepared. A recent event, where an automatic splice, installed for only 5 years, let go and dropped a line on a woman, ultimately resulting in her tragic death. The lawsuit resulted in an award of $105 Million. The manufacturer walked away untouched – because it was EVIDENT that the conductor had NOT BEEN BRUSHED, as per the instruction on the package! The only person who knows that any splice is properly installed is the person who did the installation – because the part of the conductor that must be brushed is INSIDE the connector and IS NOT visible!

- *Partial Insertion Errors – Incomplete Insertion*
  The only means of detecting this condition during inspection is with X-Ray. It is highly unlikely, unless the connector is actually within hours or days of failure, that the resistance measurements or thermal imaging will indicate this condition unless the line is really heavily loaded.

- *Partial Insertion Errors – Errant Strand*
  The only means of detecting this condition during inspection is with X-Ray, and more particularly, only if the orientation of the splice/jaws and the camera is at an acceptable angle to "see" the condition. Also, this too is highly unlikely that this condition could be detected by resistance measurements or thermal imaging.

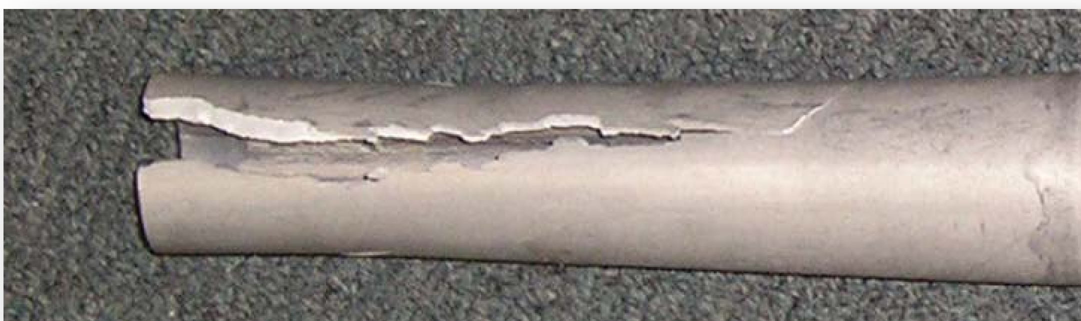
- *Lack of Inhibitor*
  If corrosive conditions are well established, and the line is heavily loaded electrically, this condition may possibly be detected with IR or resistance measurements, but actual field practice has shown mixed results with both false positives and false negatives.

Of course, finding the problem is one thing, fixing it is another. A variety of reports in the field indicate the service life of automatics is as short as seven years up to, and perhaps surpassing 20 years, however, as in the case mentioned which occurred in 2009, and culminated in the legal settlement of $105,000,000, the splice was only 5 years old (manufactured in May of 2004) having failed in 2009. To replace automatics with compression splices is very time consuming, and as a result expensive. To replace them with another automatic…. Well, one is left to wonder, did they brush this one? Did they use inhibitor? Did they fully insert the conductor properly? The same questions can be asked of the replacement compression splice. Either scenario leaves questions – including, "How long will this splice last?" Many splices used in "replacement applications on weathered conductor" are NOT rated for that application – automatics especially!

ANSI C119.4 Class A rating is for connectors being used on new – un-weathered conductor, operating at temperatures below 93°C! This especially applies to automatics, because their tension capacity is derived from a tempered aluminum barrel which, when subjected to temperatures above 93°C will begin to anneal, resulting in as much as a 70% a loss of strength!

DO NOT ALLOW THESE TYPES OF ALUMINUM BODIED CONNECTORS TO EXCEED 93°C

The result of the softening of the connector body may result in the body parting in the center, or splitting along the tapered section.



CORRECTING automatic splices or any overhead connectors with ClampStar® is faster, much less expensive, and results in a connection of significantly higher integrity than even that of the original connector! The installation can be performed without a power interruption, and the result is a thermally uprated connection, and a visible indication that your utility has taken the steps to protect the general public against the possibility of yet another powerline on the ground that occurred as the result of a failed connector.

Have you ever looked up as you were driving, and noting a splice in the conductor passing over the road, wondered if that splice was one of many that, although it is there today, may have been improperly installed, and could "let go" at any moment with no warning? Perhaps one might sleep a little better if they saw a ClampStar covering that splice, knowing that one connector had been "corrected"!